The Forest Products Laboratory

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United States Department of Agriculture
Forest Service

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Madison, Wisconsin
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FOREST PRODUCTS LABORATORY

PURPOSE AND ORGANIZATION

The Forest Products Laboratory is a laboratory of practical research conducted by the Forest Service in co-operation with the University of Wisconsin, at Madison, Wisconsin. Its aim is to promote economy and efficiency in the utilization of wood and in the processes by which forest materials are converted into commercial products.

In carrying this out the purpose is:

1. To secure authoritative information on the mechanical and physical properties of commercial woods and products secured from them.

2. To study and develop the fundamental principles underlying the seasoning and kiln drying of wood, its preservative treatment, its use for the production of fiber products (pulp, paper, fiber board, etc.), and its use in the manufacture of alcohol, turpentine, rosin, tar and other chemical products.

3. To develop practical ways and means of using wood which, under present conditions, is being wasted.

4. To co-operate with consumers of forest products in improving present methods of use; also in formulating specifications and grading rules for commercial woods and materials secured from them, and for materials used in the preservative treatment of wood.

5. To make the information secured available to the public through publications, correspondence, and other means.

The Forest Products Laboratory, Showing Receiving Yard.

Anyone is at liberty to correspond with the laboratory about particular problems dealing with the utilization of wood, and will receive an answer based on whatever information is available on the subject. Such information is, of course, furnished free. The staff of the laboratory is also available for consultation work, provided the problem under consideration has some bearing of general interest. Personal visits to the laboratory for consultation have proved very satisfactory.

The Forest Products Laboratory has a very important function in assisting in the disposal of National Forest timber that is ready for cutting. The laboratory stands in a consulting capacity to the men in actual charge of the timber sale work, and with them works out the commercial possibilities of blocks of timber that are ready for cutting and their relative value for different purposes.

The laboratory is in charge of a director, and the investigations are divided into the general lines: (1) Timber tests (strength tests), (2) timber physics, (3) pulp and paper*, (4) wood distillation, and (5) wood preservation,** The force consists of approximately eighty persons.

CO-OPERATION WITH COMPANIES, ORGANIZATIONS, AND INDIVIDUALS

It is the policy of the Forest Service to secure to as large an extent as practicable the co-operation of the

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*The experiments in the grinding of wood for mechanical pulp are conducted at Wausau, Wisconsin. The laboratory is under the supervision of the Forest Products Laboratory at Madison. (The Wausau Laboratory was discontinued December, 1913.)

**The pathological work of wood preservation is in charge of a representative of the Bureau of Plant Industry.

wood-using industries most directly concerned with the subjects or problems under investigation. The desirability of co-operation, and its exact terms will be determined in each specific case.

As a general rule, no investigation conducted by the laboratory will be regarded as complete until the results obtained experimentally have been checked on a commercial scale and their industrial application determined. This will ordinarily be accomplished through co-operation with individuals or companies using wood and who are commercially interested in the possibilities of the processes or articles in question.

After experimental results have been satisfactorily checked on a commercial scale, and their applicability to wood-using industries demonstrated, further co-operation covering the same ground will not be entered into.

The design, construction, and operation of commercial plants for wood preservation, distillation, kiln drying, and similar work may be undertaken in exceptional cases, when a new process will be demonstrated and the plant used, at least in part, for experimental work from which the Service will derive needed information. The information of the Service on such plants, including designs and specifications, will be available to anyone interested. The laboratory may also indicate the approximate cost of the construction and operation of such plants, and submit suggestions on the plans and specifications if desired. Under such circumstances, however, applicants will be referred to consulting engineers, the laboratory furnishing only such general advice and assistance as can be given at slight cost.

The laboratory may, on request, examine the methods of individuals or companies in handling forest products and prepare plans for improving such methods, provided that the purpose is primarily to reduce waste

and to obtain information of general value to the industries concerned. If no new information will probably be obtained, such work will not be undertaken. In such cases the applicant will be referred to a consulting expert.

In cases of active co-operation there should be a remuneration to the Service equivalent to the total cost of the work done for the co-operator, including both the time and expense of the members of the laboratory detailed to the project. Such remuneration may be reduced by the extent to which the work is strictly experimental, and of value chiefly to the Service rather than to the co-operator. When practically all of the work proposed is investigative, the laboratory having little or no expert knowledge on the subject to begin with, and the results will be of value chiefly to the general public, the charge to the applicant may be made comparatively low or eliminated altogether.

Whenever practicable, arrangements will be made with co-operators or others especially interested in the investigation to furnish all of the material necessary for the work.

As far as practicable, co-operative projects will be covered by written agreements. Such agreements are required whenever co-operative investigations of a specific character are to be continued for a period of six months or longer; or when the total expenditure of the Forest Service on the work proposed will exceed $100.

LINES OF WORK

MECHANICAL PROPERTIES

The tests of mechanical properties are of value to engineers, manufacturers, and other users of wood in enabling them to employ the various species and forms

Timber Testing Laboratory, Showing Machines for Determining the Strength and Stiffness of Wood.

most advantageously, and frequently to substitute species less well known for those which have been commonly used but are now becoming scarce. The investigations may be classified in four series.

Tests on Small Specimens

The first series consists of tests of small specimens which serve the following purposes:

(a) To establish scales by means of which it will be possible to directly compare the bending strength, compressive strength, shearing, stiffness, toughness, hardness, and cleavability of the commercial timbers of the United States.

(b) To correlate the properties listed above with the rate of growth, the position of the specimen in the tree, the physical characteristics of the tree, and the locality and conditions under which the tree grew.

Tests on Structural Timbers

In the second series timbers of the quality and sizes commonly used in bridges and general building construction are tested. The purposes of the tests are:

(a) To supply engineers and architects with data on which to base moduli for use in the design of structures built of timber.

(b) To correlate the results of the tests with the physical characteristics of the timber and with the character and location of defects in order to establish a more correct basis for the grading of large timbers according to their mechanical properties.

(c) To establish the relation of results obtained from test on large timbers containing defects to results obtained with small specimens free from defects so that factors will be available for applying to the latter results, thus making them of more practical significance to engineers and architects.

Tests on Manufactured Articles

Tests on axles, spokes, cross-arms, poles, and other manufactured articles form a third series. They constitute, however, a minor part of the tests, and are made primarily for the purpose of demonstrating the fitness of a substitute species or a lower grade of material for specific uses.

Effect of Preservative Treatments, Moisture, Etc.

The fourth series consists of tests for the purpose of studying the effect of preservative treatments, methods of seasoning, fireproofing, and similar processes upon the properties of wood. Both structural forms and small specimens free from defects are used in the various studies, the form and character of the specimens in each case being determined by the nature of the problem.

PHYSICAL PROPERTIES

A knowledge of the physical properties of wood is of importance to almost every industry using wood and is essential in investigations relating to kiln drying, impregnation with preservatives, distillation, and other treatments. Omitting the properties already referred to as mechanical (some of which might almost equally well be classed as physical) the more distinctly physical properties studied are hygroscopicity, density, shrinkage, transfusion of moisture, specific heat, heat conductivity, heat of absorption of water in wood, and permeability of wood to liquids and gases.

DRYING OR "CONDITIONING"

In the production of lumber, structural timber, ties, poles, vehicle and implement stock, furniture stock, and almost all other wood products, much money is spent in getting rid of the moisture and getting the wood in con-

dition for use; also much material is annually lost or damaged as a result of improper treatment. Reduction in the time required and decrease of the loss are important problems for investigation.

Air Seasoning

While proper air seasoning results in many advantages, the material is subject to damage by checking, decay, insect attack, and sap stain. It is the purpose of the investigations to assist in bettering these conditions by securing data on the proper methods of piling and the time required to air season various forms and species in various localities.

Kiln Drying

It is often necessary for financial reasons to reduce the time required to properly air season wood and, therefore, to hasten the drying process with heat. Moreover, for many purposes it is desirable to dry the wood more thoroughly than can be accomplished in the open air, and to employ conditions which will reduce its hygroscopicity or tendency to shrink and swell. For these reasons dry kilns are almost universally employed for high class lumber and frequently even for the poorer grades.

Methods at present in use are with few exceptions more or less unsatisfactory, particularly in the case of drying hardwoods, and it is estimated that about 10 per cent of the material dried is either ruined or lowered in grade. Much of this loss could be avoided by proper methods and kilns, and the present results might be greatly improved in other respects. Investigations are being made to determine the best means for drying each species of wood, and the best practical solution to the present problems in drying wood commercially.

Dry Kiln in which Humidity Circulation and Temperature can be Regulated.

High Temperature Treatments

Very little is known concerning the behavior of wood when subjected to high temperatures and pressures or to various conditions of the surrounding media. Preliminary experiments indicate that certain of the fundamental, physical and mechanical properties, such as density, strength, hardness and hygroscopicity, may be greatly affected by such treatments. Investigations are under way to study the effect of various treatments of this nature. Whether a wood naturally unsuited for a certain purpose might be so changed or transformed as to meet the requirements is one of the things to be determined by these experiments.

RELATION OF STRUCTURE TO PROPERTIES

Although a large amount of study has been done on the structure of woods, the acquired facts are not available in a form suitable for the use of those not thoroughly familiar with botany, biology, or dendrology. Information of this nature would be of value to all engaged in wood-using industries. Studies are being made of the microscopic structure of all the important native woods and photomicrographs of these woods to uniform scales of 50 and 250 magnifications are being prepared. In conducting the investigations especial attention is given to the relation of structure to the specific uses of the wood and to its mechanical and physical properties.

WOOD PRESERVATION

The extent of the field for wood preservation studies is indicated by the fact that in 1912, 126,000,000 cubic feet of wood were treated to protect it from decay. About three-fourths of this material consisted of crossties, of which 32,000,000 were treated;* in 1911, 29,000,000 treated crossties were used by steam railroads,**

*American Wood Preservers' Association, Proceedings, 1913.

** Bureau of the Census, Forest Products No. 8, "Crossties Purchased, 1910."

yet those treated were scarcely more than one-fifth the number used. If all of the ties were treated the consumption could be reduced by at least one-half, with an annual saving of $16,000,000 to the railroads. The investigations concerning wood preservation fall into several more or less distinct classes.

Preservatives

In treating operations the cost of the preservative amounts to from 50 to 90 per cent of the total cost of treatment. Furthermore, the ultimate success from any treatment is largely dependent upon the preservative used; and, although many substances have been used to greater or less extent, there are still a variety of opinions existing as to what one will give the greatest efficiency under any specific conditions. It is the purpose of the work to secure authentic information on the relative efficiency of various preservatives. The following properties are determined:

Physical and chemical properties.
Toxicity.
Effect on strength of wood.
Inflamability.
Ease of injection into wood

Processes

Closely related to the work on wood preservatives is the investigative work on preservative processes. However efficient a preservative may be in itself, it is important that it be injected into the wood in the most efficient and economical manner.

The investigations include a determination of the relative efficiency of the commercially-established processes and of new or proposed ones; also a study of the fundamental principles involved in the various conditions of temperature and pressure that make up the separate stages of a process.

Suitability of Species

A third class of wood-preservation studies deals with the suitability of various species for treatment. The relative resistance of the woods to impregnation, their resistance to decay, and the best methods of preparing them for treatment are among the factors studied.

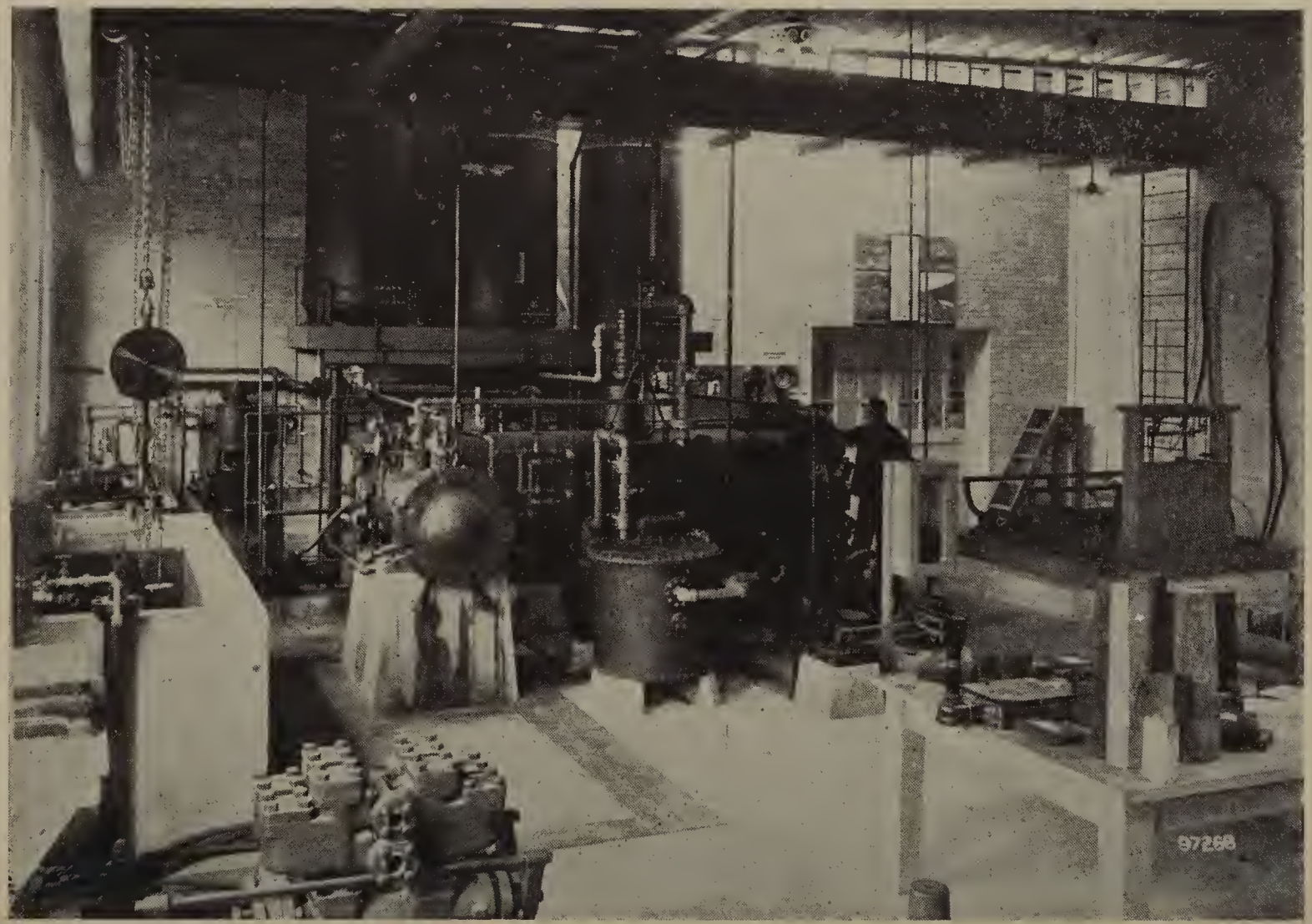
Fireproofing

The protection of wood against fire is an important field in wood preservation. The annual fire loss in the United States is estimated at twenty-five million dollars, which is about ten times as much as the fire loss in Germany. This difference is due largely to the greater proportion of wooden construction in the United States. Fireproofing is one way of checking the fire loss and at the same time cutting down the amount of material needed for rebuilding, and thus reducing the drain on our forests. The need of a method of fireproofing wood is evident.

PULP AND PAPER

During the last few years the pulp and paper industry has consumed over 4,000,000 cords of wood annually, costing approximately $35,000,000. When it is considered that the annual consumption of wood in this industry increased over 100 per cent in nine years, that of the amount used nearly 60 per cent is spruce, and that the average manufacturing cost of groundwood pulp increased from $10.84 in 1900 to $16.58 in 1909* (of which 93 per cent is accounted for by the increased cost of wood), the importance of investigations to show the value of available species and forms of wood not now generally used, and tending to increase the efficiency of the established processes is evident.

*Report of the Tariff Board Relative to Pulp and Newspaper Industry, Senate Doc. 31, 62d Congress, First Session, p. 78.



Wood Preservation Laboratory, Showing Treating Cylinders and Auxiliary Apparatus.

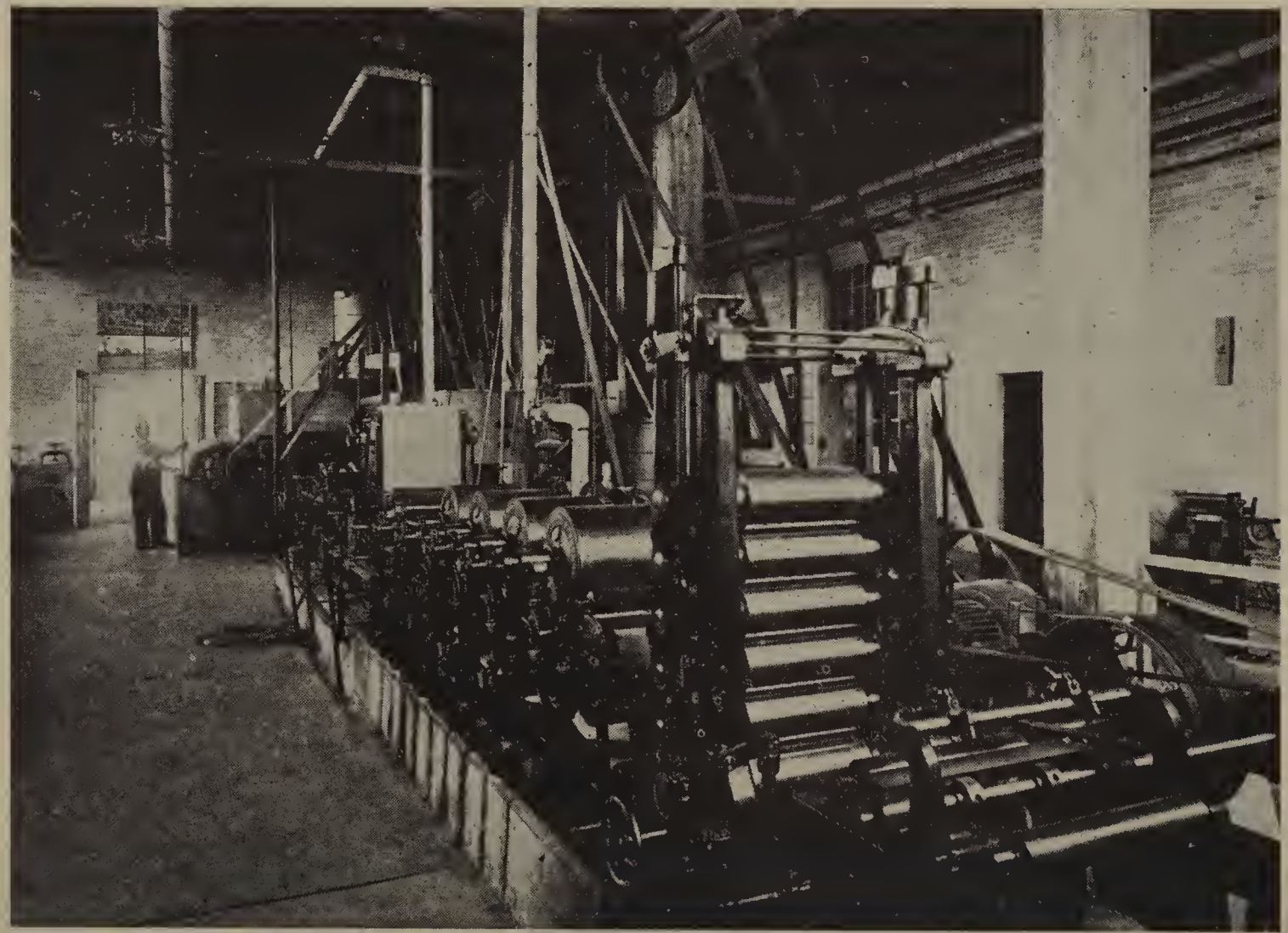
Mechanical or Grinding Processes

So far as the immediate needs of the paper trade are concerned, the investigations dealing with the production of groundwood pulp are of the greatest importance. The greater portion of the cheaper grades of paper requiring no great strength, such as newsprint, is made from pulp produced mechanically. At the present time practically the entire supply of groundwood pulp is made from spruce, and the diminishing supply and increasing price of this species make it imperative that satisfactory substitutes be found if possible. A study of various other species is being conducted.

Chemical Processes

Pulp for use in the finer and stronger grades of paper is produced by chemical processes; and, although a greater variety of woods is used than for groundwood pulp, the fundamental problem confronting the industry is also the supply of raw material. In 1909 over 85 per cent of the wood consumed consisted of the four species, spruce, hemlock, poplar and balsam. It is the aim of the investigative work to determine the relative suitability of other available species and of various forms of material, particularly mill and forest wastes.

In studying the suitability of the various woods, their adaptability for the different established processes must be considered, a thorough knowledge of the various processes must be secured, and the effects of the fundamental variable cooking conditions analyzed. The means of increasing the efficiency of the processes so as to secure larger yields of pulp or pulps with more desirable properties presents another important field for experiment. The soda, sulphite, and sulphate processes are being covered by the investigations.



Pulp and Paper Laboratory, Showing Experimental Paper Machine in Foreground.

WOOD DISTILLATION

Hardwoods

The hardwood distillation industry consumed over 1,250,000 cords of wood in 1910, costing over $4,000,000, and produced products valued at over $8,500,000. The industry is well established with fairly well standardized processes. Two of the main products, acetate of lime and wood alcohol, are regularly quoted market articles. The third, charcoal, is usually sold to iron furnaces or in other local markets for fuel. In many of the plants wood cut especially for the purpose is used, while others operate either wholly or in part on sawmill waste. Small sized material, such as sawdust and shavings, is not suitable because the charcoal produced from such material is too fine to be of commercial value.

The species most extensively used are birch, beech, and maple. The amount of valuable products that can be obtained from these woods (in mixture) is comparatively well known, but very little information is available for other species. The investigations are concerned with: (1) Determining comparative yields from various species; (2) methods of increasing the yields of valuable products; and (3) improved methods of refining the products.

Resinous Woods

Of resinous wood, 192,000 cords were distilled in 1910 which cost $780,000 and resulted in products worth about $1,134,000. While the industry is comparatively new in this country, and methods are not well standardized, it is attracting much attention and promises to play a very important part in utilizing the wastes occuring in the lumbering of southern pines. Two general classes of processes are used:

Destructive Distillation.—The largest portion of resinous woods at present used in the destructive distillation processes consists of "lightwood" from longleaf pine. Stumpwood from the same species has been used also to some extent, but the lightwood from dead trunks is commonly used since the stumpwood is more difficult to collect and prepare.

Extraction.—Not only the highly resinous "lightwood" but also material such as sawdust, slabs, and other mill waste from longleaf pine, which on account of its comparatively small resin content can not be used economically in the destructive distillation processes, may be extracted with steam for the recovery of turpentine and other volatile oils. Another method which has recently attracted considerable attention is extraction with a volatile solvent after steaming; this method recovers the rosin in addition to the volatile oils.

The investigations of the laboratory are concerned with: (1) The efficiency of the methods applied to the various species and classes of material; and (2) the quality and value of the various products which may be secured.

NAVAL STORES OR TURPENTINE AND ROSIN

The production of turpentine and rosin continues to be an important industry in the longleaf pine region, the value of the products annually produced being in the vicinity of $25,000,000. Under the methods of operations most commonly used there is considerable loss of possible products owing to unscientific methods of tapping the trees and collecting the gum. Other species than longleaf pine may prove of value for the production of naval stores. The study of new species and the refinement of operations is the main purpose of the investigative work.

Apparatus for Making Ethyl Alcohol from Sawdust.

OTHER DERIVED PRODUCTS

One of the most promising means for profitably utilizing wood waste—a means of utilization which, if realized, will be a source of heat and power of immense economic importance—is the production of ethyl alcohol. It has long been known that wood cellulose can be converted into fermentable sugars by treatment with acids, and a number of attempts have been made and are being made to apply this principle commercially in the production of industrial alcohol from sawdust. From the commercial standpoint such a venture is highly speculative at the present time. For the purpose of ascertaining whether the production of ethyl alcohol from sawdust is feasible commercially, and what are the best methods of procedure, apparatus has been installed to conduct experiments on a semi-commercial scale. A number of difficulties are encountered in the design of such apparatus because of the corrosive action of the chemicals which are employed—especially at the high temperatures necessary in the process.

Other products which are derived from forest materials and are, therefore, within the scope of the work of the laboratory are tannins, essential oils extracted from the bark or leaves of various trees, and producer gas manufactured from wood (usually sawmill waste). The chemical derivatives of cellulose, while not yet touched upon, also offer a fertile field for investigation.